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DETERMINATION OF RADIUM-226 IN URANIUM BEARING REFERENCE MATERIALS FOR CERTIFICATION PURPOSES

Final Report

by

MONENGO ANALYTICAL LABORATORIES

Work on this project was conducted under the auspices of the Canada Centre for Mineral and Energy Technology, Energy, Mines and Resources, Canada.

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1.0 INTRODUCTION

This work was undertaken to measure the radium-226 activity contents in each of four Canadian Certified Reference Materials Project (CCRUP) uranium and uranium-thorium ore materials. The materials, identified as BL-5, BL4a, DH-1a and DL-1a were analysed by Dr. N. Chiu and Dr. J. Dean using high resolution alpha spectrometry. The methodology is described below.

2.0 ANALYTICAL PROCEDURES

All samples were analysed as received. That is, the moisture contents of each sample were considered to be negligible. Analyses were carried out on exactly one gram aliquots of each material. Each material was analysed 4 times. All samples were put into solution by KF-pyrosulphate fusion[1]. The resulting solution was then analysed for ^{226}Ra by coprecipitation with lead sulphate/barium sulphate followed by isolation of barium sulphate after complexation of thorium with DTPA[2,3,4]. The source consisting of barium sulphate was analysed by alpha spectrometry for radium-226 content. Sample recovery was measured by the use of the gamma emitter, barium-133. In order to avoid interference in the gamma counting by bismuth-214 these measurements were made as soon as possible after source preparation and prior to significant radium-226 daughter grow-in.

3.0 ANALYTICAL RESULTS

3.01 Alpha Spectrometer Calibration

The geometric factor of each alpha spectrometer was determined from sources prepared using ASTM reference standard 4957. The resulting solution had a radium-226 activity (corrected to December 1982) of 36.014 BQ/ML (973.4 pCi/mL). Table 1 contains the calculations and volume used to obtain that concentration. The ASTM certificate for standard 4957 is included in Appendix A.

The data used to calculate the geometric factors for each detector are included on pages to . The precision of each measurement includes the contribution from the ASTM standard uncertainty of ±1.8%. Alpha spectrometer 2 was used for samples BL-5 and BL-4a, while alpha spectrometers 3 and 4 were used for DL-1a and DH-1a.

TABLE I

STANDARD CALIBRATION SOLUTION PREPARED FROM

RADIUM-226 ASTM REFERENCE STANDARD 4957

- Ampoule certified to contain 0.4957±0.0089 micrograms of Radium-226 as of September 1, 1967.

- Corrected to December, 1982 the ampoule contains

$$0.4957 \; \text{e}^{-\frac{0.693 \times 15.2}{1600}} = 0.4924 \text{ micrograms}$$

- Contents of ampoule made up to solution of 500 ml with water.

Composition of Solution:

$$= \frac{3.657 \times 10^{10} \text{ BQ/gm} \times 0.4924 \times 10^{-6} \text{ gm}}{500 \text{ ml}} = 36.014 \text{ BQ/ML}$$

$$= 973.4 \text{ pCi/ml} \left(36.04 \text{ BQ/ML} \times 27.027 \frac{\text{pCi}}{\text{BQ}}\right)$$

3.02 Radium-276 Contents of the Standard Ores

Table II shows a summary of the radium-226 contents determined in each subsample of the four standards. The data are expressed in units of pCi/g and in units of BQ/g. The components used to calculate the precision of each measurement are included in the tables that follow. It should be noted that the weight of each sample was exactly one gram.

TABLE II

SUMMARY OF ANALYSIS

Units of pCi/g

Sample Description (Run No.)	Radium-226 pCi/g	Radium-226 BQ/g
BL-5 (I)	22,032±140	815±5
(II)	22,536±143	834±5
(III)	22,722±140	841±5
(IV)	22,499±139	832±5
Average(n=4)	22,447±293	= 830±11
	22.4±0.3 nCi/g	
BL-4a (I)	413.3±2.6	15.29±0.10
(II)	417.0±2.4	15.43±0.09
(III)	424.1±2.5	15.69±0.09
(IV)	428.7±2.4	15.86±0.09
Average(n=4)	= 421. ±7.	= 15.6 ±0.2
DL-1a (I)	38.09±0.25	1.409±0.009
(II)	39.73±0.26	1.470±0.010
(III)	40.98±0.26	1.516±0.010
(IV)	39.82±0.29	1.455±0.011
Average (n=4)	39.5 ±1.2	= 1.46 ±0.04
DH-1a (V)	895.0±6.1	33.12±0.22
(VI)	868.9±5.6	32.15±0.21
(VII)	878.2±6.1	32.49±0.22
(VIII)	900.0±5.4	33.30±0.20
Average(n=4)	886. ±14.	= 32.76±0.52

4.0 BIBLIOGRAPHY

(1) Sill, C.W., "Fusion", Anal. Chem., 49, 618 (1977).

(2) Smithson, G.L., "Radiochemical Procedures For Determination of Selected Members of the Uranium and Thorium Series", CANMET Report No. 78-22 (1979).

(3) Sill, C.W., "Separation and Radiochemical Determination of Uranium And The Trans-Uranium Elements Using Barium Sulfate", Health Phys., 17, 89 (1969).

(4) Sill, C.W., Williams, R.L., "Radiochemical Determination of Uranium and The Trans-Uranium Elements In Process Solutions And Environmental Samples". Anal. Chem. 41, 1624 (1969).

APPENDIX A

ASTM CERTIFICATE FOR STANDARD 4957

U. S. Department of Commerce
Alexander B. Trowbridge,
Secretary

National Bureau of Standards
A. V. Astin, Director

Certificate

Standard Reference Material 4957
Gamma-Ray Standard
Radium—226

This standard consists of radium-226 in approximately 5 milliliters of solution in a flame-sealed glass ampoule. The solution is 5 percent by weight HNO_3.

The weight, in micrograms, of radium-226 contained in the ampoule as of September 1, 1967, was

[illegible] ± 1.8_3%.

This standard was calibrated by comparing its gamma-ray-emission rate with those of a 1957 series of standards prepared from material that had been compared in the National Bureau of Standards radiation balance, with the national radium standards. The gamma-ray-emission rates were compared in a $4\pi\gamma$ ionization chamber containing argon at a pressure of 10 atmospheres.

The uncertainty, 1.8_3 percent, is the sum of 1.0_3 percent, which is the statistical error at the 99-percent confidence level (2.58 s_m, where s_m is the standard error), and 0.8_0 percent, which is the maximum uncertainty due to assessable systematic errors in the 1957 series of standards and in the ionization-chamber comparisons.

This standard was calibrated in the Center for Radiation Research by members of the Radioactivity Section, W. B. Mann, Chief.

Washington, D. C. 20234
March 1, 1968

W. Wayne Meinke, Chief
Office of Standard Reference Materials

4957 –[illegible]

APPENDIX B

RAW DATA USED FOR CALCULATION OF GEOMETRIC FACTORS

MONENCO ANALYTICAL LABORATORIES,CALGARY,ALBERTA,CANADA

CALCULATION OF GEOMETRIC FACTOR FOR ALPHA SPECTROMETER NUMBER 2

DATE: 16 / 12 / 1982

The determination of the geometric factor is made by measuring the Ra-226 and Ba-133 activity on two sources resulting from a double precipitation with barium sulphate.The radium and barium contents of the standard discs were theoretically 973.4 pCi and 6500.191 CPM ,respectively

PRELIMINARY INFORMATION

GROSS BACKGROUND COUNTS FOR Ra-226	11
COUNTING TIME,MINUTES	73
GROSS BACKGROUND COUNTS FOR Ba-133	315
COUNTING TIME,MINUTES	10

DISC A INFORMATION

GROSS COUNTS UNDER Ra-226 PEAK	69033
COUNTING TIME	183
COUNTING TIME FOR DISC A	120
GROSS COUNTS FOR Ba-133	59919
COUNTING TIME,MINUTES	15

DISC B INFORMATION

GROSS COUNTS UNDER Ra-226 PEAK	26907
COUNTING TIME FOR DISC B,MINUTES	969
GROSS COUNTS FOR Ba-133	3341
COUNTING TIME,MINUTES	10

THE GEOMETRIC FACTOR FOR THIS ALPHA SPECTROMETER IS .27e6874 DETERMINED WITH A PRECISION OF 5.4451455E-03 .THE TRACER RECOVERY WAS .845976

CALCULATION OF GEOMETRIC FACTOR FOR ALPHA SPECTROMETER NUMBER 2

DATE: 17 / 12 / 1982

The determination of the geometric factor is made by measuring the Ra-226 and Ba-133 activity on two sources resulting from a double precipitation with barium sulphate.The radium and barium contents of the standard discs were theoretically 973.4 pCi and 6500.191 CPM ,respectively

PRELIMINARY INFORMATION

GROSS BACKGROUND COUNTS FOR Ra-226	32
COUNTING TIME,MINUTES	282
GROSS BACKGROUND COUNTS FOR Ba-133	56
COUNTING TIME,MINUTES	2

DISC A INFORMATION

GROSS COUNTS UNDER Ra-226 PEAK	46035
COUNTING TIME	99
COUNTING TIME FOR DISC A	99
GROSS COUNTS FOR Ba-133	4788
COUNTING TIME,MINUTES	10

DISC B INFORMATION

GROSS COUNTS UNDER Ra-226 PEAK	21652
COUNTING TIME FOR DISC B,MINUTES	974
GROSS COUNTS FOR Ba-133	1104
COUNTING TIME,MINUTES	5

THE GEOMETRIC FACTOR FOR THIS ALPHA SPECTROMETER IS .2898435 DETERMINED WITH A PRECISION OF 5.607115E-03 .THE TRACER RECOVERY WAS .7611038

NUCLEAR ANALYTICAL LABORATORIES,CALGARY,ALBERTA,CANADA

CALCULATION OF GEOMETRIC FACTOR FOR ALPHA SPECTROMETER NUMBER 2

DATE: 16 / 12 / 1982

The determination of the geometric factor is made by measuring the Ra-226 and Ba-133 activity on two sources resulting from a double precipitation with barium sulphate.The radium and barium contents of the standard discs were theoretically 973.4 pCi and 6500.191 CPM ,respectively

PRELIMINARY INFORMATION

GROSS BACKGROUND COUNTS FOR Ra-226	32
COUNTING TIME,MINUTES	282
GROSS BACKGROUND COUNTS FOR Ba-133	315
COUNTING TIME,MINUTES	10

DISC A INFORMATION

GROSS COUNTS UNDER Ra-226 PEAK	94888
COUNTING TIME	24e
COUNTING TIME FOR DISC A	24e
GROSS COUNTS FOR Ba-133	59919
COUNTING TIME,MINUTES	15

DISC B INFORMATION

GROSS COUNTS UNDER Ra-226 PEAK	2274
COUNTING TIME FOR DISC B,MINUTES	60
GROSS COUNTS FOR Ba-133	3743
COUNTING TIME,MINUTES	10

THE GEOMETRIC FACTOR FOR THIS ALPHA SPECTROMETER IS .2957169 DETERMINED WITH A PRECISION OF 5.469785E-03 .THE TRACER RECOVERY WAS .645976

CALCULATION OF GEOMETRIC FACTOR FOR ALPHA SPECTROMETER NUMBER 3

DATE: 3 / 1 / 1983

The determination of the geometric factor is made by measuring the Ra-226 and Ba-133 activity on two sources resulting from a double precipitation with barium sulphate.The radium and barium contents of the standard discs were theoretically 973.4 pCi and 6500.191 CPM ,respectively

PRELIMINARY INFORMATION

GROSS BACKGROUND COUNTS FOR Ra-226	143
COUNTING TIME,MINUTES	2221
GROSS BACKGROUND COUNTS FOR Ba-133	315
COUNTING TIME,MINUTES	10

DISC A INFORMATION

GROSS COUNTS UNDER Ra-226 PEAK	120491
COUNTING TIME	366
COUNTING TIME FOR DISC A	366
GROSS COUNTS FOR Ba-133	55918
COUNTING TIME,MINUTES	15

DISC B INFORMATION

GROSS COUNTS UNDER Ra-226 PEAK	659
COUNTING TIME FOR DISC B,MINUTES	30
GROSS COUNTS FOR Ba-133	2341
COUNTING TIME,MINUTES	10

THE GEOMETRIC FACTOR FOR T-16 ALPHA SPECTROMETER IS .250748 DETERMINED WITH A PRECISION OF 4.659875-03 .THE TRACER RECOVERY WAS .66E976

MOMENCO ANALYTICAL LABORATORIES,CALGARY,ALBERTA,CANADA

CALCULATION OF GEOMETRIC FACTOR FOR ALPHA SPECTROMETER NUMBER 3

DATE: 6 / 1 / 1983

The determination of the geometric factor is made by measuring the Ra-226 and Ba-133 activity on two sources resulting from a double precipitation with barium sulphate.The radium and barium contents of the standard discs were theoretically 973.4 pCi and 6510.191 CPM ,respectively

PRELIMINARY INFORMATION

GROSS BACKGROUND COUNTS FOR Ra-226	143
COUNTING TIME,MINUTES	2221
GROSS BACKGROUND COUNTS FOR Ba-133	44
COUNTING TIME,MINUTES	2

DISC A INFORMATION

GROSS COUNTS UNDER Ra-226 PEAK	3[illegible]27
COUNTING TIME	95[illegible]
COUNTING TIME FOR DISC A	95[illegible]
GROSS COUNTS FOR Ba-133	8[illegible]7[illegible]
COUNTING TIME,MINUTES	2[illegible]

DISC B INFORMATION

GROSS COUNTS UNDER Ra-226 PEAK	49[illegible]
COUNTING TIME FOR DISC B,MINUTES	2[illegible]
GROSS COUNTS FOR Ba-133	[illegible]630
COUNTING TIME,MINUTES	2[illegible]

THE GEOMETRIC FACTOR FOR THIS ALPHA SPECTROMETER IS .[illegible] DETERMINED WITH A PRECISION OF 4.[illegible]E-03 .THE TRACER RECOVERY WAS .[illegible]

CALCULATION OF GEOMETRIC FACTOR FOR ALPHA SPECTROMETER NUMBER 4

DATE: 3 / 1 / 1983

The determination of the geometric factor is made by measuring the Ra-226 and Ba-133 activity on two sources resulting from a double precipitation with barium sulphate.The radium and barium contents of the standard discs were theoretically 973.4 pCi and 6500.191 CPM ,respectively

PRELIMINARY INFORMATION

GROSS BACKGROUND COUNTS FOR Ra-226	130
COUNTING TIME,MINUTES	2221
GROSS BACKGROUND COUNTS FOR Ba-133	315
COUNTING TIME,MINUTES	10

DISC A INFORMATION

GROSS COUNTS UNDER Ra-226 PEAK	1183c
COUNTING TIME	30
COUNTING TIME FOR DISC A	30
GROSS COUNTS FOR Ba-133	5891[illegible]
COUNTING TIME,MINUTES	15

DISC B INFORMATION

GROSS COUNTS UNDER Ra-226 PEAK	1019[illegible]
COUNTING TIME FOR DISC B,MINUTES	3c6
GROSS COUNTS FOR Ba-133	3041
COUNTING TIME,MINUTES	1[illegible]

THE GEOMETRIC FACTOR FOR THIS ALPHA SPECTROMETER IS .3[illegible]E-5 DETERMINED WITH A PRECISION OF 6.[illegible]E-12 ,THE TRACER RECOVERY WAS .64597[illegible]

CALCULATION OF GEOMETRIC FACTOR FOR ALPHA SPECTROMETER NUMBER 4

DATE: 6 / 1 / 1983

The determination of the geometric factor is made by measuring the Ra-226 and Ba-133 activity on two sources resulting from a double precipitation with barium sulphate.The radius and barium contents of the standard discs were theoretically 973.4 pCi and 6500.191 CPM ,respectively

PRELIMINARY INFORMATION

GROSS BACKGROUND COUNTS FOR Ra-226	130
COUNTING TIME,MINUTES	2221
GROSS BACKGROUND COUNTS FOR Ba-133	44
COUNTING TIME,MINUTES	2

DISC A INFORMATION

GROSS COUNTS UNDER Ra-226 PEAK	82910
COUNTING TIME	20
COUNTING TIME FOR DISC A	210
GROSS COUNTS FOR Ba-133	51170
COUNTING TIME,MINUTES	20

DISC B INFORMATION

GROSS COUNTS UNDER Ra-226 PEAK	56826
COUNTING TIME FOR DISC B,MINUTES	956
GROSS COUNTS FOR Ba-133	6630
COUNTING TIME,MINUTES	20

THE GEOMETRIC FACTOR FOR THIS ALPHA SPECTROMETER IS .294287+ DETERMINED WITH A PRECISION OF .1.03847 .THE TRACER RECOVERY WAS .6695958

APPENDIX C

RAW DATA USED FOR CALCULATION OF ^{226}Ra CONTENT OF ORES

MONENCO ANALYTICAL LABORATORIES,CALGARY,ALBERTA,CANADA

MEASUREMENT OF Ra-226 CONTENT OF CANMET STANDARD ORES

SAMPLE DESCRIPTION:	BL-5-I

PRELIMINARY INFORMATION

GROSS BACKGROUND COUNTS FOR Ra-226	11
BACKGROUND COUNTING TIME,MINUTES	73
GROSS BACKGROUND COUNTS FOR Ba-133	315
BACKGROUND COUNTING TIME,MINUTES	10
GEOMETRIC FACTOR	.299 +/- .001
AMT. Ba-133 TRACER USED	6500.191 CPM

UNKNOWN SAMPLE DATA

GROSS COUNTS FOR Ra-226	72883
COUNTING TIME,MINUTES	5
GROSS COUNTS FOR Ba-133	65912
COUNTING TIME,MINUTES	10

UNKNOWN SAMPLE DESCRIBED AS BL-5-I CONTAINS 22031.05 pCi/Gram OF RADIUM-226 MEASURED WITH A 1 SIGMA PRECISION OF 139.6909 pCi/Gram

MONENCO ANALYTICAL LABORATORIES,CALGARY,ALBERTA,CANADA

MEASUREMENT OF Ra-226 CONTENT OF CANMET STANDARD ORES

SAMPLE DESCRIPTION:	BL-5-II

PRELIMINARY INFORMATION

GROSS BACKGROUND COUNTS FOR Ra-226	11
BACKGROUND COUNTING TIME,MINUTES	73
GROSS BACKGROUND COUNTS FOR Ba-133	315
BACKGROUND COUNTING TIME,MINUTES	10
GEOMETRIC FACTOR	.299 +/- .001
AMT. Ba-133 TRACER USED	6500.191 CPM

UNKNOWN SAMPLE DATA

GROSS COUNTS FOR Ra-226	74697
COUNTING TIME,MINUTES	5
GROSS COUNTS FOR Ba-133	66032
COUNTING TIME,MINUTES	10

UNKNOWN SAMPLE DESCRIBED AS BL-5-II CONTAINS 22535.80 pCi/Gram OF RADIUM-226 MEASURED WITH A 1 SIGMA PRECISION OF 142.5516 pCi/Gram

MINERCO ANALYTICAL LABORATORIES,CALGARY,ALBERTA,CANADA

MEASUREMENT OF Ra-226 CONTENT OF CANMET STANDARD ORES

SAMPLE DESCRIPTION:	BL-5-III

PRELIMINARY INFORMATION

GROSS BACKGROUND COUNTS FOR Ra-226	11
BACKGROUND COUNTING TIME,MINUTES	73
GROSS BACKGROUND COUNTS FOR Ba-133	315
BACKGROUND COUNTING TIME,MINUTES	10
GEOMETRIC FACTOR	.298 +/- .001
AMT. Ba-133 TRACER USED	6500.191 DPM

UNKNOWN SAMPLE DATA

GROSS COUNTS FOR Ra-226	90270
COUNTING TIME,MINUTES	6
GROSS COUNTS FOR Ba-133	65965
COUNTING TIME,MINUTES	10

UNKNOWN SAMPLE DESCRIBED AS BL-5-IIICONTAINS 22721.67 pCi/Gram OF RADIUM-226 MEASURED WITH A 1 SIGMA PRECISION OF 139.5438 pCi/Gram

MINERCO ANALYTICAL LABORATORIES,CALGARY,ALBERTA,CANADA

MEASUREMENT OF Ra-226 CONTENT OF CANMET STANDARD ORES

SAMPLE DESCRIPTION:	BL-5-IV

PRELIMINARY INFORMATION

GROSS BACKGROUND COUNTS FOR Ra-226	11
BACKGROUND COUNTING TIME,MINUTES	73
GROSS BACKGROUND COUNTS FOR Ba-133	315
BACKGROUND COUNTING TIME,MINUTES	10
GEOMETRIC FACTOR	.298 +/- .001
AMT. Ba-133 TRACER USED	6500.191 DPM

UNKNOWN SAMPLE DATA

GROSS COUNTS FOR Ra-226	75376
COUNTING TIME,MINUTES	5
GROSS COUNTS FOR Ba-133	72423
COUNTING TIME,MINUTES	11

UNKNOWN SAMPLE DESCRIBED AS BL-5-IVCONTAINS 22498.88 pCi/Gram OF RADIUM-226 MEASURED WITH A 1 SIGMA PRECISION OF 139.7267 pCi/Gram

SCIENCE ANALYTICAL LABORATORIES,CALGARY,ALBERTA,CANADA

MEASUREMENT OF Ra-226 CONTENT OF CANMET STANDARD ORES

SAMPLE DESCRIPTION: BL-4a-I

PRELIMINARY INFORMATION

GROSS BACKGROUND COUNTS FOR Ra-226	11
BACKGROUND COUNTING TIME,MINUTES	73
GROSS BACKGROUND COUNTS FOR Ba-133	315
BACKGROUND COUNTING TIME,MINUTES	10
GEOMETRIC FACTOR	.298 +/- .001
AMT. Ba-133 TRACER USED	6500.191 CPM

UNKNOWN SAMPLE DATA

GROSS COUNTS FOR Ra-226	75691
COUNTING TIME,MINUTES	380
GROSS COUNTS FOR Ba-133	62485
COUNTING TIME,MINUTES	11

UNKNOWN SAMPLE DESCRIBED AS BL-4a-I CONTAINS 413.279 pCi/Gram OF RADIUM-226 MEASURED WITH A 1 SIGMA PRECISION OF 2.642987 pCi/Gram

SCIENCE ANALYTICAL LABORATORIES,CALGARY,ALBERTA,CANADA

MEASUREMENT OF Ra-226 CONTENT OF CANMET STANDARD ORES

SAMPLE DESCRIPTION: BL-4a-II

PRELIMINARY INFORMATION

GROSS BACKGROUND COUNTS FOR Ra-226	11
BACKGROUND COUNTING TIME,MINUTES	73
GROSS BACKGROUND COUNTS FOR Ba-133	315
BACKGROUND COUNTING TIME,MINUTES	10
GEOMETRIC FACTOR	.298 +/- .001
AMT. Ba-133 TRACER USED	6500.191 CPM

UNKNOWN SAMPLE DATA

GROSS COUNTS FOR Ra-226	166373
COUNTING TIME,MINUTES	819
GROSS COUNTS FOR Ba-133	72950
COUNTING TIME,MINUTES	15

UNKNOWN SAMPLE DESCRIBED AS BL-4a-II CONTAINS 417.0449 pCi/Gram OF RADIUM-226 MEASURED WITH A 1 SIGMA PRECISION OF 2.035173 pCi/Gram

MINERCO ANALYTICAL LABORATORIES,CALGARY,ALBERTA,CANADA

MEASUREMENT OF Ra-226 CONTENT OF CANMET STANDARD ORES

SAMPLE DESCRIPTION: BL-4a-III

PRELIMINARY INFORMATION

GROSS BACKGROUND COUNTS FOR Ra-226	11
BACKGROUND COUNTING TIME,MINUTES	73
GROSS BACKGROUND COUNTS FOR Ba-133	315
BACKGROUND COUNTING TIME,MINUTES	10
GEOMETRIC FACTOR	.299 +/- .001
AMT. Ba-133 TRACER USED	6500.191 CPM

UNKNOWN SAMPLE DATA

GROSS COUNTS FOR Ra-226	107719
COUNTING TIME,MINUTES	415
GROSS COUNTS FOR Ba-133	73934
COUNTING TIME,MINUTES	13

UNKNOWN SAMPLE DESCRIBED AS BL-4a-IIICONTAINS 424.1922 pCi/Gram OF RADIUM-226 MEASURED WITH A 1 SIGMA PRECISION OF 2.489141 pCi/Gram

MINERCO ANALYTICAL LABORATORIES,CALGARY,ALBERTA,CANADA

MEASUREMENT OF Ra-226 CONTENT OF CANMET STANDARD ORES

SAMPLE DESCRIPTION: BL-4a-II

PRELIMINARY INFORMATION

GROSS BACKGROUND COUNTS FOR Ra-226	11
BACKGROUND COUNTING TIME,MINUTES	73
GROSS BACKGROUND COUNTS FOR Ba-133	315
BACKGROUND COUNTING TIME,MINUTES	10
GEOMETRIC FACTOR	.299 +/- .001
AMT. Ba-133 TRACER USED	6500.191 CPM

UNKNOWN SAMPLE DATA

GROSS COUNTS FOR Ra-226	211691
COUNTING TIME,MINUTES	1149
GROSS COUNTS FOR Ba-133	64340
COUNTING TIME,MINUTES	15

UNKNOWN SAMPLE DESCRIBED AS BL-4a-IICONTAINS 428.6724 pCi/Gram OF RADIUM-226 MEASURED WITH A 1 SIGMA PRECISION OF 2.424945 pCi/Gram

MINERCO ANALYTICAL LABORATORIES,CALGARY,ALBERTA,CANADA

MEASUREMENT OF Ra-226 CONTENT OF CANMET STANDARD ORES

SAMPLE DESCRIPTION: DL-1a-II

PRELIMINARY INFORMATION

GROSS BACKGROUND COUNTS FOR Ra-226	143
BACKGROUND COUNTING TIME,MINUTES	2221
GROSS BACKGROUND COUNTS FOR Ba-133	315
BACKGROUND COUNTING TIME,MINUTES	10
GEOMETRIC FACTOR	.254 +/- .001
AMT. Ba-133 TRACER USED	6500.191 CPM

UNKNOWN SAMPLE DATA

GROSS COUNTS FOR Ra-226	51149
COUNTING TIME,MINUTES	2464
GROSS COUNTS FOR Ba-133	146179
COUNTING TIME,MINUTES	24

UNKNOWN SAMPLE DESCRIBED AS DL-1a-IICONTAINS 39.72709 pCi/Gram OF RADIUM-226 MEASURED WITH A 1 SIGMA PRECISION OF .2561916 pCi/Gram

MINERCO ANALYTICAL LABORATORIES,CALGARY,ALBERTA,CANADA

MEASUREMENT OF Ra-226 CONTENT OF CANMET STANDARD ORES

SAMPLE DESCRIPTION: DL-1a-IV

PRELIMINARY INFORMATION

GROSS BACKGROUND COUNTS FOR Ra-226	143
BACKGROUND COUNTING TIME,MINUTES	2221
GROSS BACKGROUND COUNTS FOR Ba-133	315
BACKGROUND COUNTING TIME,MINUTES	10
GEOMETRIC FACTOR	.254 +/- .001
AMT. Ba-133 TRACER USED	6500.191 CPM

UNKNOWN SAMPLE DATA

GROSS COUNTS FOR Ra-226	42140
COUNTING TIME,MINUTES	2671
GROSS COUNTS FOR Ba-133	65524
COUNTING TIME,MINUTES	14

UNKNOWN SAMPLE DESCRIBED AS DL-1a-IVCONTAINS 39.7165 pCi/Gram OF RADIUM-226 MEASURED WITH A 1 SIGMA PRECISION OF .2919765 pCi/Gram

MONENCO ANALYTICAL LABORATORIES,CALGARY,ALBERTA,CANADA

MEASUREMENT OF Ra-226 CONTENT OF CANMET STANDARD ORES

SAMPLE DESCRIPTION:	DL-1a-III
PRELIMINARY INFORMATION	
GROSS BACKGROUND COUNTS FOR Ra-226	130
BACKGROUND COUNTING TIME,MINUTES	2221
GROSS BACKGROUND COUNTS FOR Ba-133	315
BACKGROUND COUNTING TIME,MINUTES	10
GEOMETRIC FACTOR	.305 +/- .001
Art. Ba-133 TRACER USED	6500.191 CPM
UNKNOWN SAMPLE DATA	
GROSS COUNTS FOR Ra-226	66239
COUNTING TIME,MINUTES	2464
GROSS COUNTS FOR Ba-133	70052
COUNTING TIME,MINUTES	11

UNKNOWN SAMPLE DESCRIBED AS DL-1a-IIICONTAINS 41.98126 pCi/Gram OF RADIUM-226 MEASURED WITH A 1 SIGMA PRECISION OF .26196119 pCi/Gram

MONENCO ANALYTICAL LABORATORIES,CALGARY,ALBERTA,CANADA

MEASUREMENT OF Ra-226 CONTENT OF CANMET STANDARD ORES

SAMPLE DESCRIPTION:	DL-1a-I
PRELIMINARY INFORMATION	
GROSS BACKGROUND COUNTS FOR Ra-226	130
BACKGROUND COUNTING TIME,MINUTES	2221
GROSS BACKGROUND COUNTS FOR Ba-133	315
BACKGROUND COUNTING TIME,MINUTES	10
GEOMETRIC FACTOR	.305 +/- .001
Art. Ba-133 TRACER USED	6500.191 CPM
UNKNOWN SAMPLE DATA	
GROSS COUNTS FOR Ra-226	63047
COUNTING TIME,MINUTES	2671
GROSS COUNTS FOR Ba-133	60281
COUNTING TIME,MINUTES	10

UNKNOWN SAMPLE DESCRIBED AS DL-1a-ICONTAINS 39.9881 pCi/Gram OF RADIUM-226 MEASURED WITH A 1 SIGMA PRECISION OF .25157318 pCi/Gram

MINENCO ANALYTICAL LABORATORIES,CALGARY,ALBERTA,CANADA

MEASUREMENT OF Ra-226 CONTENT OF CANMET STANDARD ORES

SAMPLE DESCRIPTION: DH-1a-V

PRELIMINARY INFORMATION

GROSS BACKGROUND COUNTS FOR Ra-226	143
BACKGROUND COUNTING TIME,MINUTES	2221
GROSS BACKGROUND COUNTS FOR Ba-133	44
BACKGROUND COUNTING TIME,MINUTES	2
GEOMETRIC FACTOR	.239 +/- .001
AMT. Ba-133 TRACER USED	6500.191 CPM

UNKNOWN SAMPLE DATA

GROSS COUNTS FOR Ra-226	47337
COUNTING TIME,MINUTES	100
GROSS COUNTS FOR Ba-133	121510
COUNTING TIME,MINUTES	20

UNKNOWN SAMPLE DESCRIBED AS DH-1a-V CONTAINS 894.9774 pCi/Gram OF RADIUM-226 MEASURED WITH A 1 SIGMA PRECISION OF 6.150524 pCi/Gram

MINENCO ANALYTICAL LABORATORIES,CALGARY,ALBERTA,CANADA

MEASUREMENT OF Ra-226 CONTENT OF CANMET STANDARD ORES

SAMPLE DESCRIPTION: DH-1a-VII

PRELIMINARY INFORMATION

GROSS BACKGROUND COUNTS FOR Ra-226	143
BACKGROUND COUNTING TIME,MINUTES	2221
GROSS BACKGROUND COUNTS FOR Ba-133	44
BACKGROUND COUNTING TIME,MINUTES	2
GEOMETRIC FACTOR	.239 +/- .001
AMT. Ba-133 TRACER USED	6500.191 CPM

UNKNOWN SAMPLE DATA

GROSS COUNTS FOR Ra-226	48270
COUNTING TIME,MINUTES	100
GROSS COUNTS FOR Ba-133	101810
COUNTING TIME,MINUTES	20

UNKNOWN SAMPLE DESCRIBED AS DH-1a-VII CONTAINS 876.1978 pCi/Gram OF RADIUM-226 MEASURED WITH A 1 SIGMA PRECISION OF 6.119961 pCi/Gram

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MINERAL ANALYTICAL LABORATORIES,CALGARY,ALBERTA,CANADA

MEASUREMENT OF Ra-226 CONTENT OF CANMET STANDARD ORES

SAMPLE DESCRIPTION: DH-1a-V.

PRELIMINARY INFORMATION

GROSS BACKGROUND COUNTS FOR Ra-226	183
BACKGROUND COUNTING TIME,MINUTES	2221
GROSS BACKGROUND COUNTS FOR Ba-133	44
BACKGROUND COUNTING TIME,MINUTES	2
GEOMETRIC FACTOR	.294 +/- .001
AMT. Ba-133 TRACER USED	6500.191 CPM

UNKNOWN SAMPLE DATA

GROSS COUNTS FOR Ra-226	48426
COUNTING TIME,MINUTES	108
GROSS COUNTS FOR Ba-133	104150
COUNTING TIME,MINUTES	20

UNKNOWN SAMPLE DESCRIBED AS DH-1a-V CONTAINS 888.6781 pCi/Gram OF RADIUM-226 MEASURED WITH A 1 SIGMA PRECISION OF 8.452215 pCi/Gram

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MINERAL ANALYTICAL LABORATORIES,CALGARY,ALBERTA,CANADA

MEASUREMENT OF Ra-226 CONTENT OF CANMET STANDARD ORES

SAMPLE DESCRIPTION: DH-1a-VIII

PRELIMINARY INFORMATION

GROSS BACKGROUND COUNTS FOR Ra-226	140
BACKGROUND COUNTING TIME,MINUTES	2221
GROSS BACKGROUND COUNTS FOR Ba-133	44
BACKGROUND COUNTING TIME,MINUTES	2
GEOMETRIC FACTOR	.294 +/- .001
AMT. Ba-133 TRACER USED	6500.191 CPM

UNKNOWN SAMPLE DATA

GROSS COUNTS FOR Ra-226	65362
COUNTING TIME,MINUTES	124
GROSS COUNTS FOR Ba-133	109961
COUNTING TIME,MINUTES	20

UNKNOWN SAMPLE DESCRIBED AS DH-1a-VIII CONTAINS 9[illegible] pCi/Gram OF RADIUM-226 MEASURED WITH A 1 SIGMA PRECISION OF 8.471697 pCi/Gram